DECLASS REVIEW by NIMA/DOD

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REPORT STAT

VERTICAL SPACING OF LIQUID BEARINGS

RM-140-65

February 1965

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FOREWORD

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[redacted] submits this report in compliance with Item 4.2 of the Development Objectives of [redacted] This report should be read in conjunction with Report [redacted] of which it forms a part.

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Approved: [redacted]

Research Manager

ABSTRACT

The primary objective was to determine a suitable vertical spacing for liquid bearings. In order to meet this requirement, a mockup test stand was constructed. Two upper rollers and one lower roller were mounted on the test stand to simulate a film transport system. Type 4400 film was selected and was prewet to simulate processing conditions. Small increments of weight were applied to one end of the film until the force required to maintain a safe operating separation between the sides of the film loops was determined.

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1. INTRODUCTION

Tests were conducted to determine the maximum vertical bearing spacing required to eliminate any damaging effects to film resulting from solution turbulence caused by liquid bearings. The following liquid-bearing sizes were investigated: 1-1/2, 1-3/4, and 2 inch diameters, plus a 1/8-inch liquid cushion height.

2. TECHNICAL DISCUSSION

2.1 MATERIALS AND EQUIPMENT

Principal materials and equipment used for experiments and tests are listed below:

1) Mockup test stand with an adjustable frame which controlled the vertical positioning of the upper liquid bearings to a maximum height of 3 feet (Figure 2-1).

2) 1-1/2, 1-3/4, and 2-inch diameter rubber and PVC rollers, plus a 1/8-inch liquid cushion height.

3) Type 4400 film, 9-1/2 inches wide by 12 feet in length

4) Small lead weights

5) Force gage indicator, [redacted] Model No. L-20, Serial No. 1170, zero to 20 pounds. STAT

2.2 EXPERIMENTAL PROCEDURE

Twelve-foot lengths of Type 4400 film were soaked in 90°F water for five minutes to approximate the flexibility of film undergoing standard processing. The film was then threaded on the roller array. A 180-degree film wrap on each bearing was precisely maintained throughout the test series to automatically determine the correct horizontal spacing regardless of bearing diameter.

To simulate film agitation or the fluttering action inherent with liquid bearings, a small air blower was held about one inch from the surface of the film. This proved inadequate for simulating the desired effect. To achieve the desired effect, small weights were applied to one end of the film until the weight was sufficient to remove the slack between loops on the adjacent rollers. Once this weight was established, a force gage was slowly pressed against the surface of the film until it touched the adjacent loop. A reading of 12.8 ounces was recorded. This 12.8-ounce reading was considered a constant. In each subsequent test, regardless of the diameter or vertical separation of the rollers, weights were added to one end of the wet film until the force gage read 12.8 ounces (Figure 2-2)..

2.3 RESULTS

Using vertical heights of 24 and 36 inches and applying the same 12.8-ounce force, the amount of weight required to maintain safe separation between the loops of film varied according to the diameter of the roller used and the height selected. Typical results are given below:

1) 36-inch vertical height:
   1788.3 gr for 1-3/4-inch roller
   1634.5 gr for 2-inch roller
   1567.3 gr for 2-1/4-inch roller

2) 24-inch vertical height:
   1324.3 gr for 1-3/4 inch roller
   1170.5 gr for 2-inch roller
   1119.8 gr for 2-1/4-inch roller

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 VERTICAL SPACING

While the test conducted under these simulated conditions indicated that a vertical distance of 36 inches between liquid bearings would be feasible (using any of the bearing diameters tested and assuming that the proper tension is applied to the transport system) it is by no means conclusive.

The static condition of the test rack cannot fairly reproduce the dynamic effects encountered in an operating processor. Other experiments performed in conjunction with this phase of the contract clearly demonstrated the powerful cohesive forces generated by the Bernoulli effect of liquid moving between the film loops.

It is strongly recommended, therefore, that the test be repeated with moving film, different loads, and different types of film before definitive results can be assured.

Predictably, for each of the two vertical bearing spacings, the smaller diameters required greater force than the larger. This agrees with our research on the forces required to attain certain specified bend radii. The percentage increase in force was approximately linear with the same increase in diameter at a constant vertical spacing and, again, approximately linear with increase in vertical spacing (diameter remaining constant). This is shown graphically in Figures 3-1 and 3-2.

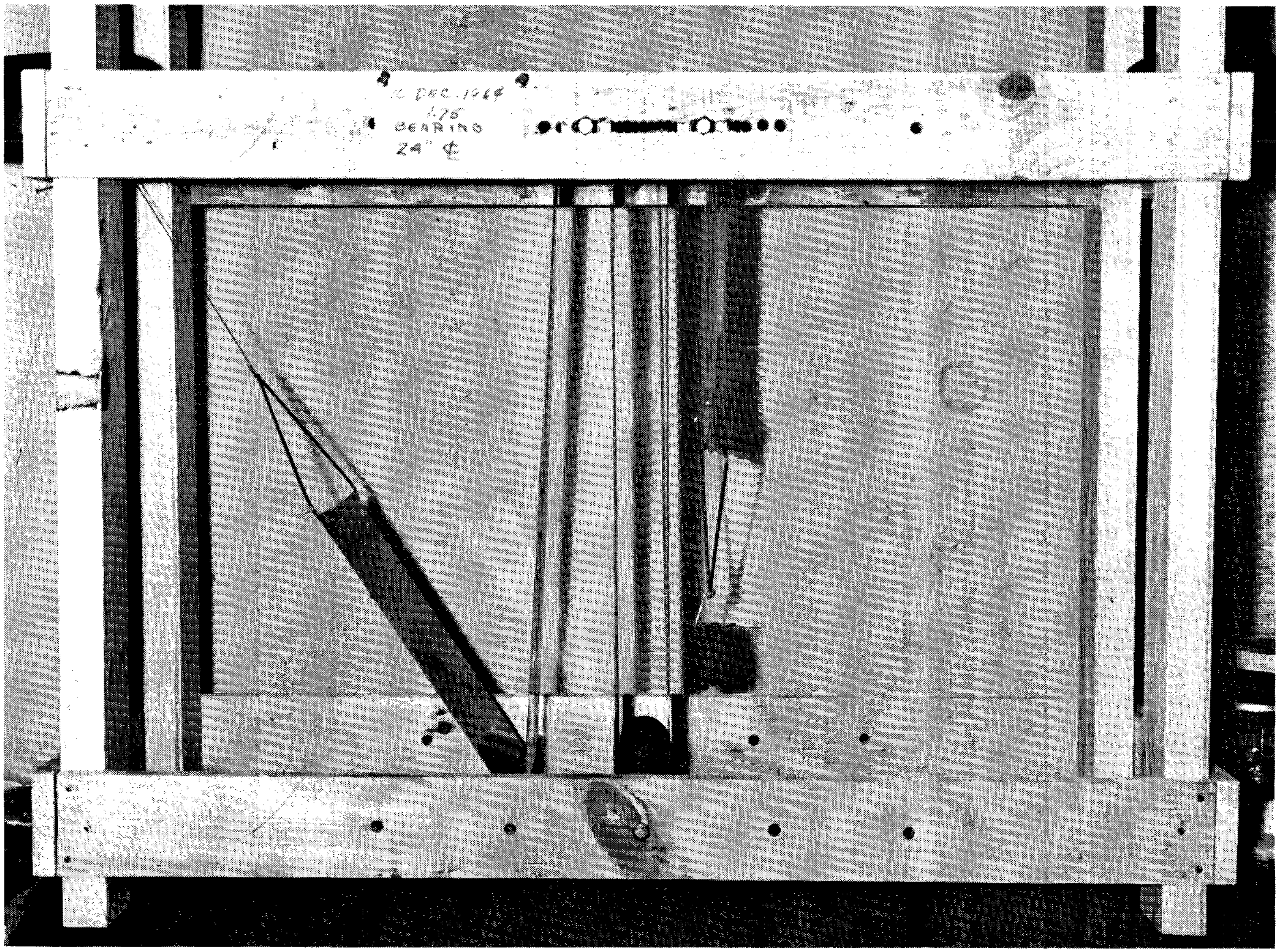

Figure 2-1. Mock-Up Test Stand

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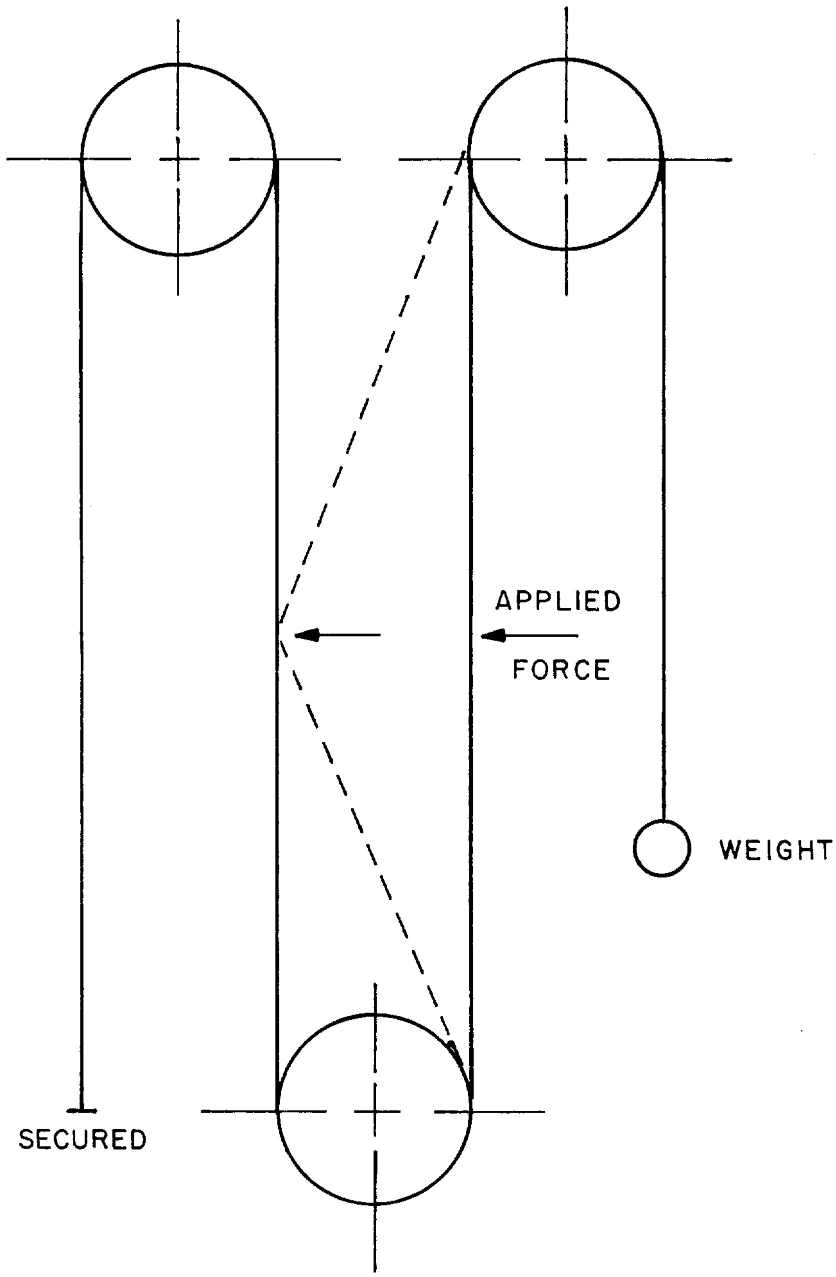

Figure 2-2. Schematic Test Apparatus

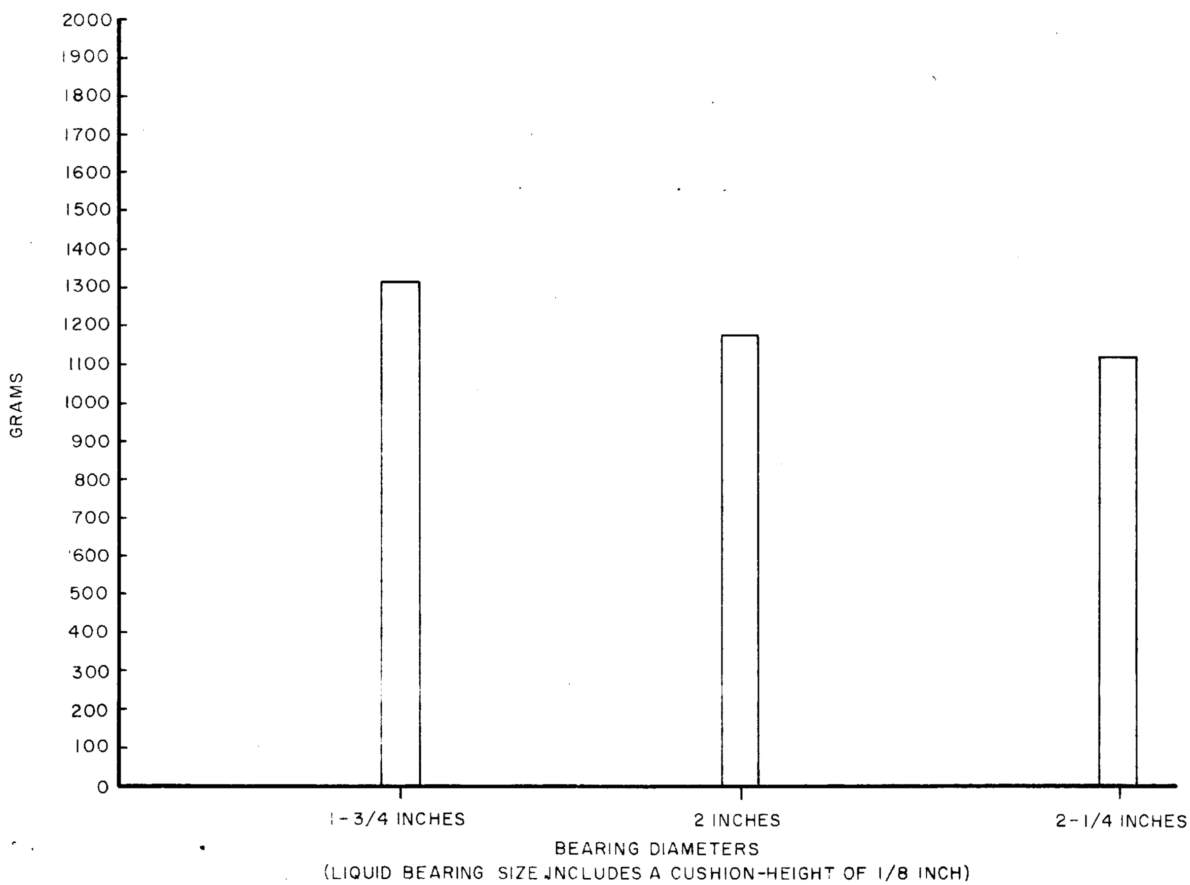

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Figure 3-1. 24 Inch Vertical Height

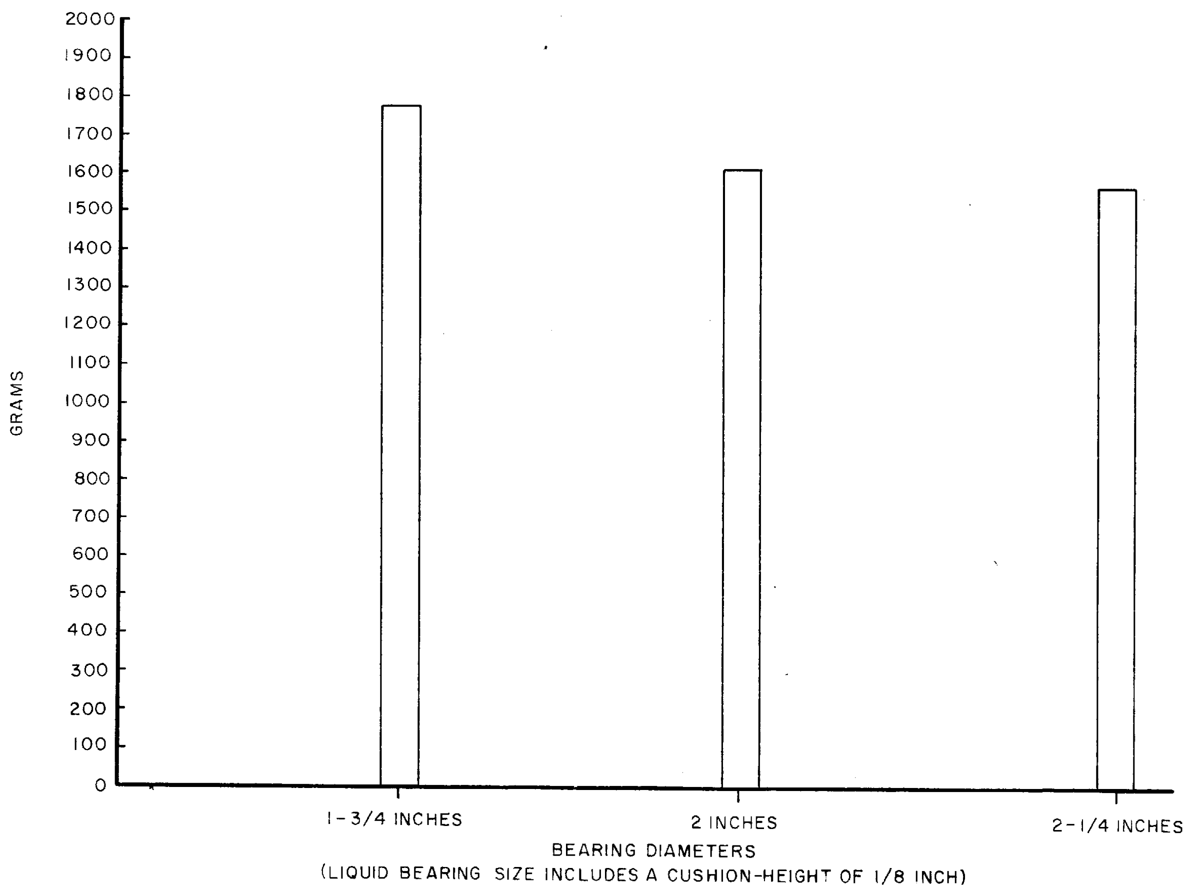

Figure 3-2. 36 Inch Vertical Height

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